KNOW...
THE MASTER OF THE ARABIAN SEA

PURPLE-BACK FLYING SQUID

Sthenoteuthis oualaniensis

Central Marine Fisheries Research Institute
Kochi, Kerala

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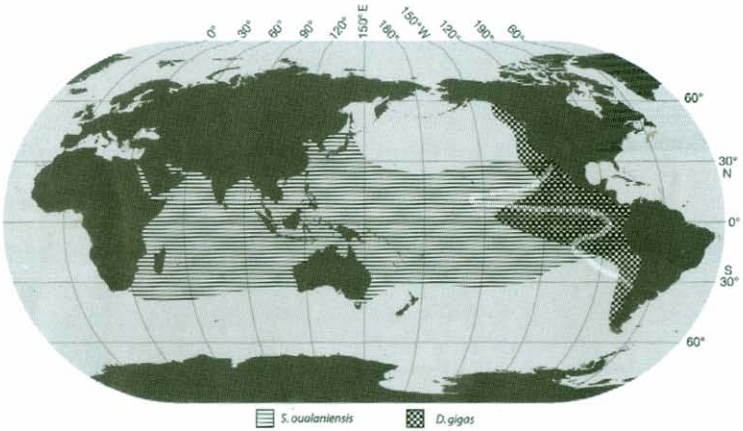
Introduction

Sthenoteuthis oualaniensis (Lesson, 1830) commonly known as the Indo-Pacific purple-back flying squid, is a true ocean dweller widely distributed in the equatorial and tropical waters of Indo-Pacific region.

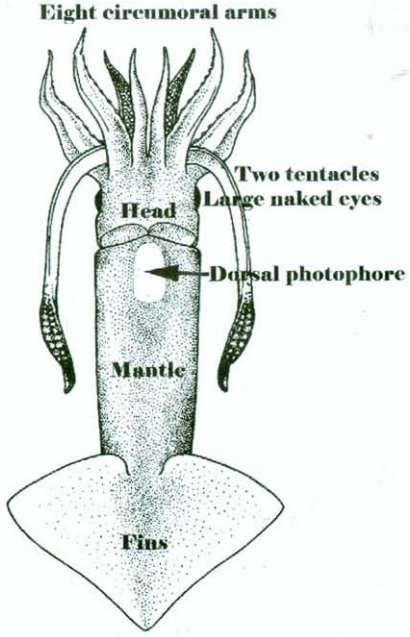


Global distribution pattern of *S. oualaniensis*

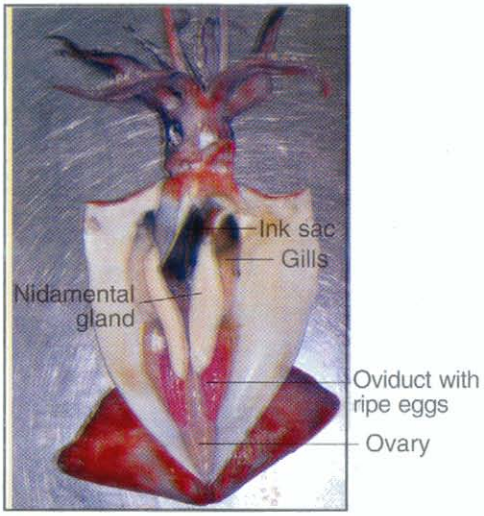
The oceanic squids unlike the neretic squids have a pelagic lifestyle in the open ocean and are rarely encountered in the commercial catches from inshore waters. The squid is characterized by a wide ecological amplitude, complex intraspecific structure, high growth rate, high fecundity, short life cycle, high natural mortality, and significant production. These large oceanic squids completely monopolize the trophic niche of the top predators in the Arabina Sea and therefore is known as the Master of the Arabian Sea.

Morphology & Anatomy

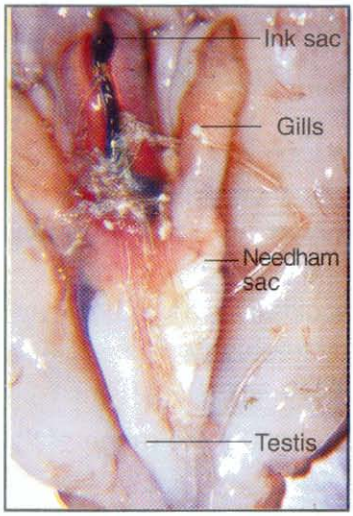
The oceanic squids are one of the most highly developed invertebrates, adapted to an active predatory life. Body of the squid comprise of the head, mantle and fins along the sides. Head consist of eight arms arranged in pairs and two long tentacles. The animal moves in water by jet propulsion, by taking water into its mantle cavity and then expelling it with great force. In oceanic squids, unlike coastal squids eyes are without any protective membrane and are surrounded by free eyelids. Large eyes are an important adaptation that helps these animals locate food in the darkness of the deep ocean.



Body colouration of *S. oualaniensis* under normal condition is red-brown along the dorsal part with large oval luminous photophoric patch on anterodorsal surface of mantle. The colouration changes in a moment with excitation. The skin is covered with chromatophores, which enables the squid to change colour to suit its surroundings. They have complex nervous system and highly developed brain.



Female anatomy



Male anatomy

Adult *S. oualaniensis* have a muscular funnel; robust mantle which has a cylindrical anterior and conical posterior half. Fins are large, rhombic, and muscular, with a blunt back end; their width is 70 to 85% of mantle length, length 40 to 50% of mantle length; males have wider fins than females; a large, oval photophore on the dorsal side of mantle is common which serves to attract prey.

Reddish or purple colour of *S. oualaniensis*

Population Structure

Sthenoteuthis oualaniensis have a complex population structure that incorporates three major forms.

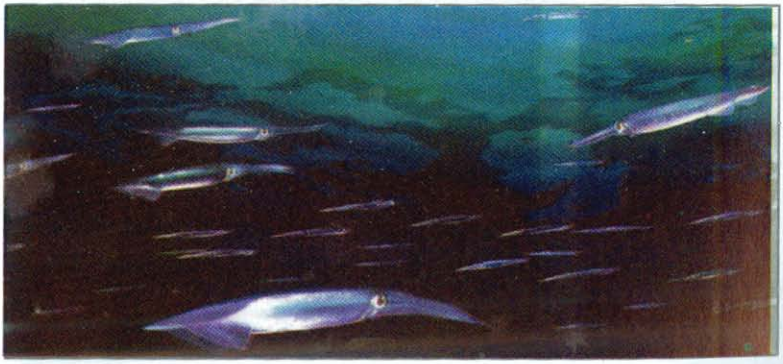
1) A giant form that occurs only in the northern Indian Ocean in the region of the Red Sea, Gulf of Aden and Arabian Sea (modal sizes of 40-50 cm mantle length in the Arabian Sea, maximum size of 65 cm mantle length).

2) A middle form, is the "typical" one (modal sizes of 12-15 cm for mature males and 19-25 cm for mature females) that occurs throughout the range of the species.

3) A dwarf form (modal size of 9-10 cm mantle length for mature males and 9-12 cm mantle length for mature females, 14-15 cm mantle length maximum) that occurs in equatorial waters and lacks the dorsal mantle photophore patch characteristic of the species.

Typical harvest length and weight range observed in the Arabian Sea

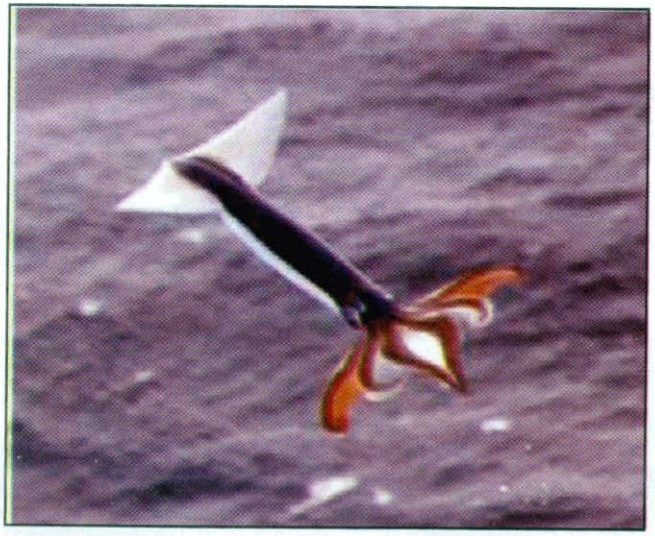
Fishing Method	Lengths (cm)	Weights (g)
Jigging	10-25	50-650
Gillnetting	20-35	300-1800



Life Cycle

Generally, females grow faster than males. The duration of life cycle in dwarf form of *S. oualaniensis* is estimated as 6 months and middle-sized as well as giant forms as one year. The largest daily increment in length in the middle-sized form is 1.0 mm, while in the giant female it is 3.8 mm. The monthly production of 1 year old giants are 9 times that of middle-sized squids of the same age.

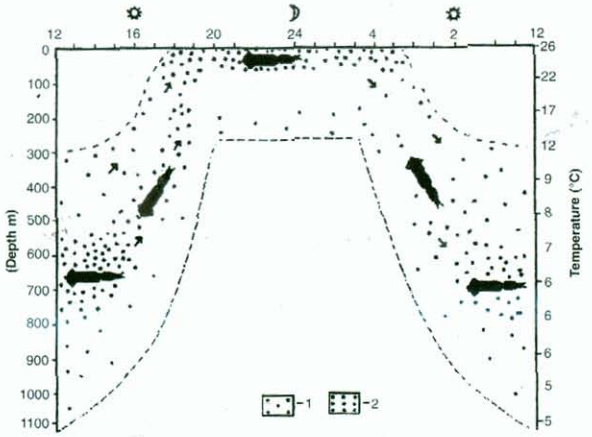
S. oualaniensis live in the water column undergoing diel vertical migrations up to 1000 m depths. Larvae are planktonic, juveniles are often associated with the continental slope. They avoid the bottom of the sea even in day time. In the continental slope area, while they descend to the near-bottom layer, they remain 2-3 m away from the bottom.



The form, and structure of squid mantle, arms, funnel and fins, their changes during ontogeny characterize these squids as powerful swimmers for which high horizontal speed is important

than maneuverability. In general, movements are characterized by high cruising speed (3-10 km/h; ML 15-35 cm) and high rush speed/ burst swimming (25-35 km/h). Maximal locomotory activity is inherent in young animals of ML 3-10 cm. Juvenile *Sthenoteuthis* can reach such high speeds that they can leap out of the water and fly some distance in the air (with tail first). During the flight, *S. oualaniensis* extends thin protective membranes on the III arms and use them as a second fin (functioning as caudal fin). Locomotory activity decreases strongly in large squids of ML greater than 45-50 cm.

Vertical distributions change during growth. In the Arabian Sea giant forms have been observed between 400-1100 m depths in the daytime which migrate to 50 to 150 m at night time. In contrast, medium sized females have been observed at 50-200 m in the day and at depths of 0-100 m in the night. The middle sized form and young squids occur near the surface. Medium sized *S. oualaniensis* (<15 cm ML) aggregate in shoals of up to 50-60 individuals. The shoals become smaller as they grow and larger females (>27 cm) often do not form schools.

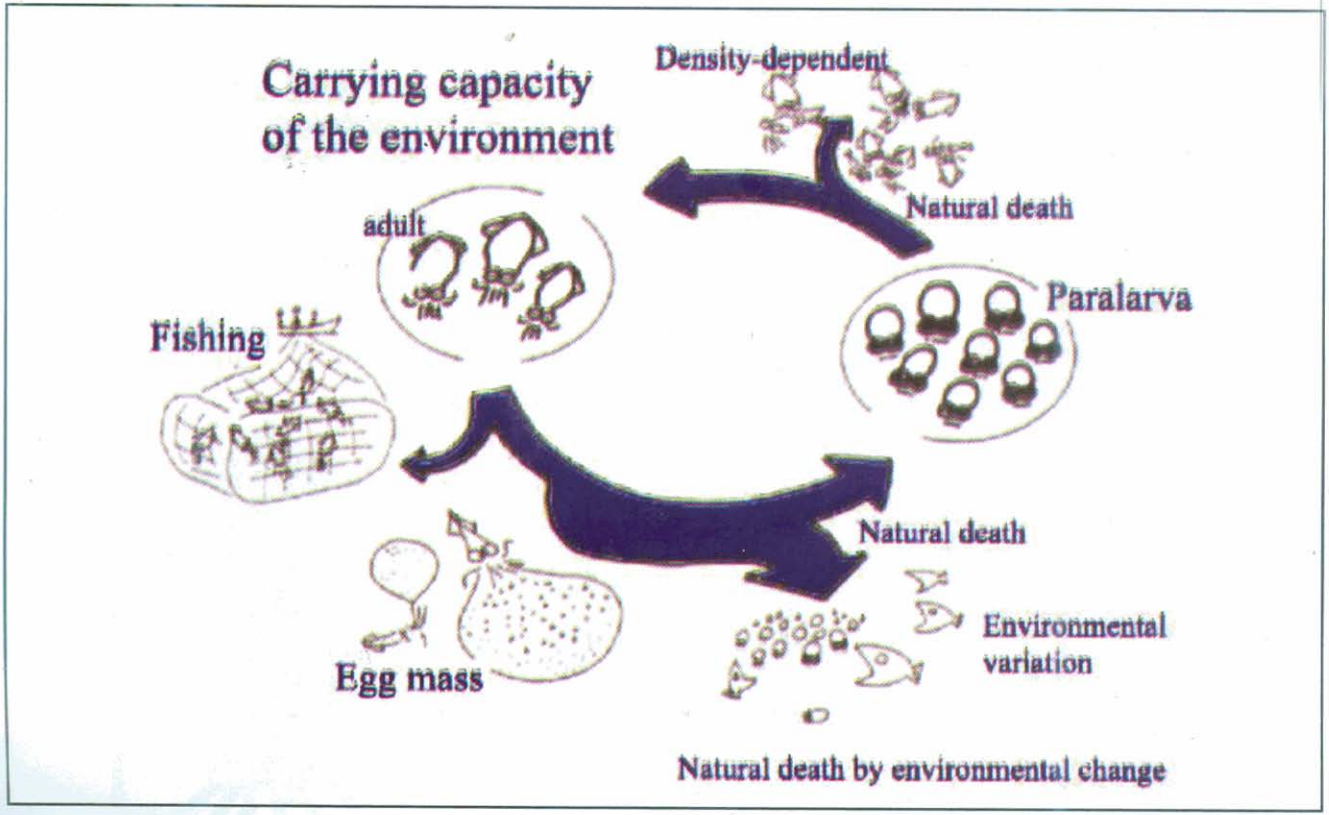


Vertical distribution of *S. oualaniensis*; 1 - Isolated individuals 2 - High density

Depths occupied by this species are low in oxygen. *S. oualaniensis* has a very high metabolic rate (standard metabolism of 348 ml O_2/kg/h) that exceeds that of many fast swimming oceanic fishes. Common with other squid species, energy metabolism is based mostly on protein: however, in *S. oualaniensis*, during metabolism a considerable proportion of the protein is catabolised anaerobically, thus enabling these squid to inhabit zones of very low oxygen concentration.

Studies suggest that the fishing ground of squid was closely related to the marine environmental variables such as SST, sea surface height (SSH), wind, chlorophyll *a* and zooplankton. The optimum SST of the fishing ground is 25-28°C. Most high-yield fishing grounds were distributed in the waters near sea surface height anomalies, SSHA<0, and the optimal range of salinity in the surface water is from 35.5 to 36.5 psu.

Estimations of daily food ration of adult *S. oualaniensis* show very high requirements for maintaining their active mode of life. The average daily ration for middle-sized squids of 15-35 cm ML was determined as 5-10% body weight, while the rations of the majority of adult pelagic fishes is 1-5% BW.



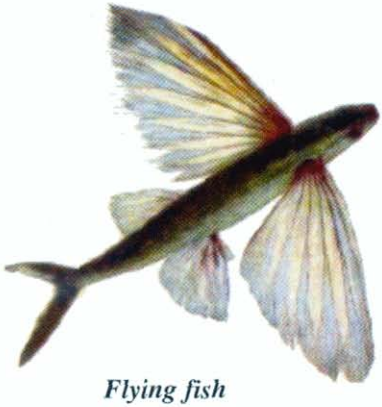
Graphic representation of oceanic squid life cycle showing influence of environmental factors

Squid Diets - What do they eat?

Fast growth rates and high metabolism indicate the requirement of high food intake. *S. oualaniensis* is an active predator with a wide food spectrum varying geographically as well as with mantle lengths.

In the stages of paralarvae and early juveniles, the squid mainly predate on crustaceans. Young feed mainly on amphipods, euphausiids and fish larvae. On the fishing ground of high daily catch (over 5 tonnes), zooplankton mainly consists of Chaetognatha (average biomass of 9.18 mg/m), Copepoda (2.32 mg/m) and Mysidacea (1.38 mg/m). These three species were also found in the stomachs of squid and could be considered as indicator species for a squid fishing ground. In the Arabian Sea, the squid of larger than 20 cm ML fed mainly on small flying fish. As the size of squid increased, the smaller squids *S. oualaniensis* became progressively more important in the diet and by 40 cm ML, squids comprised more than 50% of the diet (extreme cannibalism).

Oceanic Squid



Flying fish

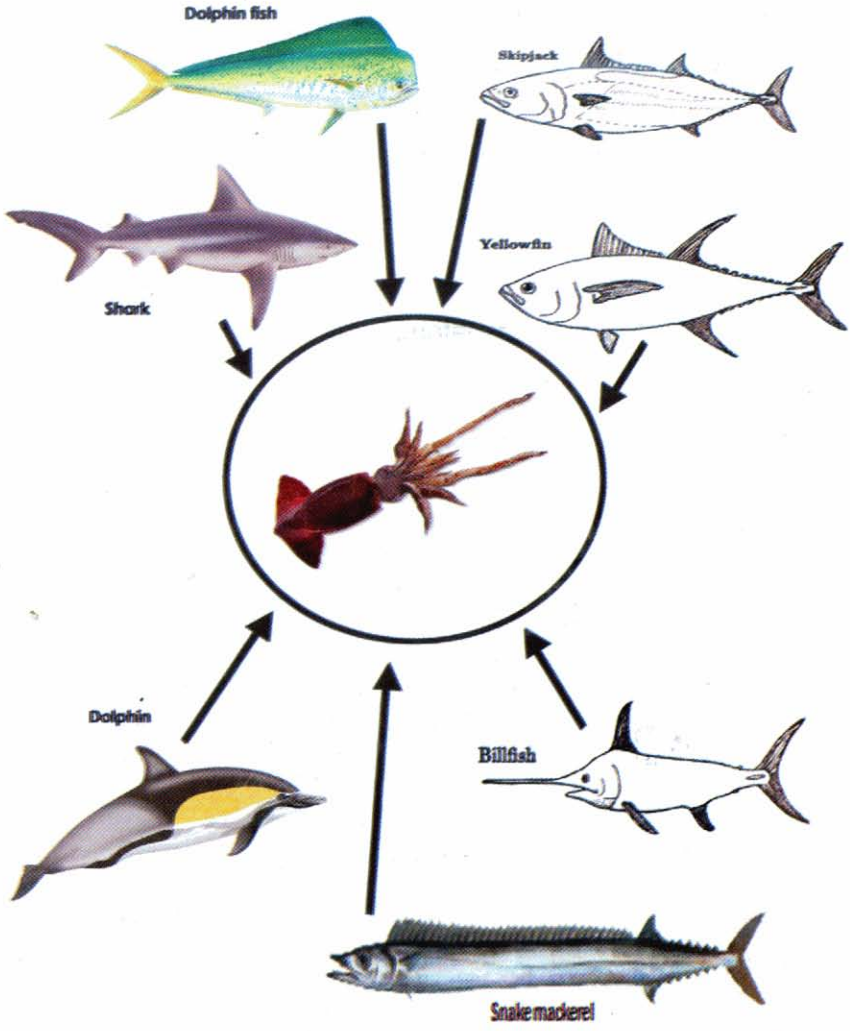
Early juveniles are active-grazing predators, late juveniles and middle-sized squids are predator-pursuers, while large-sized adults are attacking predators. Nevertheless, the giant females of *S. oualaniensis* in Arabian Sea consume mainly myctophids, which are numerous and inactive in the layer 100-200 m, hence they remain as active-grazed predators instead of large nektonic predators.

Predators - Who eats them?

The early juveniles and paralarvae of squids are the prey for a wide variety of predators including small squids, large chaetognaths, jellyfishes, carnivorous fishes etc. Squid juveniles from 3-10 cm are prey to large squids, tunas (skipjack tuna, yellowfin tuna, wahoo, bigeye tuna) dolphin fish, snake mackerel (*Gempylus serpens*), lancet fish and small sharks. Main predators of middle-sized squids are dolphins, swordfish and some active species of sharks. Large-sized squids are inaccessible for tunas and they have fewer predators: adult swordfishes, dolphins, toothed whales and large sharks. A variety of studies indicated the presence of *S. oualaniensis* in the stomach of various predators.

In Arabian Sea, large oceanic predators rarely occur, therefore the oceanic squids, owing to its high abundance, large size, short life span, fast growth and high food ration almost completely monopolize the trophic niche of the top predators. Hence, they are called as the Master of the Arabian Sea.

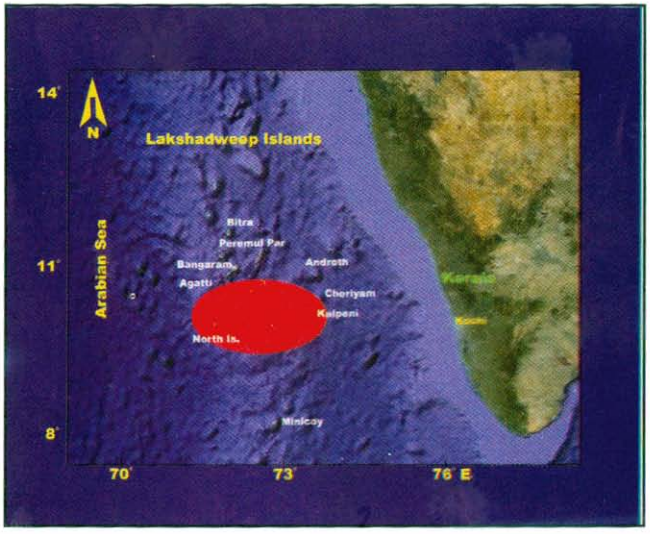
Some of the major predators of *S. oualaniensis are given on page 15.*


Dolphin fish
Skipjack
Shark
Yellowfin
Dolphin
Billfish
Snake mackerel

Reproduction & Spawning

In *S. oualaniensis* sexes are separate. Female reproductive organs consist of ovary, with thin walled as well as glandular portions; the paired nidamental glands and seminal receptacles. Ripe eggs are pinkish or raspberry coloured. Males have a unilobed testis and the male genital duct is a white, fluid-filled sac in the posterior end of the mantle. Sperms are stored in thin tubes (spermatophores) in an elongated sac behind and along the left gill.

There is indirect evidence that *S. oualaniensis* is a multiple spawner where intermittent spawning occurs over an extended period. Spawning lasts for 1-3 months at a relatively stable level without a decrease in feeding rate, with significant growth. The frequency of spawning episodes within this period are unknown. Accumulation of eggs in the oviducts is a continuous process. Spawning is not linked to the bottom and occurs in epipelagic zones. Spermatophores are stored for a long period in seminal

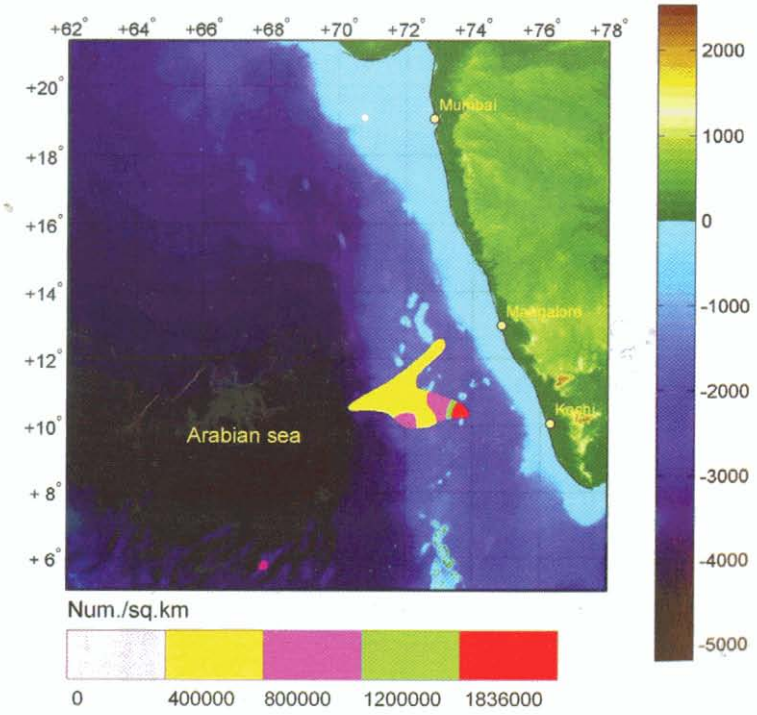


Spawning ground of oceanic squids located in the Arabian Sea

receptacles on the buccal membranes in females consequent to mating. Potential fecundity depends on the adult female size varying from 0.3 to 22 million eggs and relative fecundity ranges from 3,000- 7,000 oocytes per g body weight.

Egg masses of *S. oualaniensis* consist of a translucent mucus in which many pale crimson eggs of 0.72-0.86 mm are dispersed at a density of about 1-2 eggs/cm^3 (maximal volume of 25 l).

In *S. oualaniensis*, spawning grounds have been located in the seas around Lakshadweep Islands during post-monsoon. After the spawning period, juveniles are abundant in the surface waters at densities ranging from 0.5 to 1.8 million numbers/km^2 (See map below).

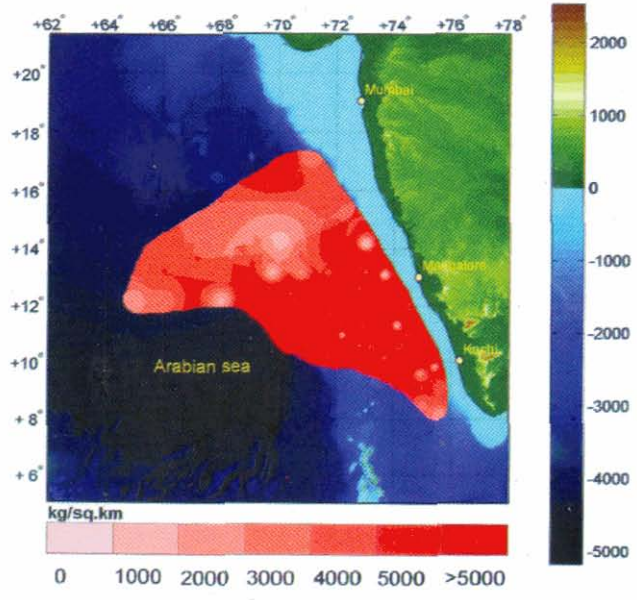


Map showing juvenile abundance near Lakshadweep Islands during post-monsoon period

Fishery & Stock Abundance

The purple-back flying squids are distributed in open oceans and are rather scattered; this has impeded their commercial exploitation. In the North Pacific, historic fishing activity for *S. oualaniensis* occurred predominantly off Okinawa, Taiwan, Vietnam and Hawaii where it is dip-netted or jigged at the surface during day and night. The species supports local fisheries from June to November in Okinawa and from March to November in Taiwan, with peak fishing from May to August.

China has successfully exploited some important oceanic squids since 1989 from around the world. In 2005, a small-scale Chinese commercial jigging fishery for *S. oualaniensis* started in the Arabian Sea, yielding more than 5000 t in production. Fishing



Composite abundance map of oceanic squid *Sthenoteuthis oualaniensis* in the Arabian Sea during 2010-11

occurs predominantly by automated jigging using lights to attract the squid. India is now making attempts to tap this resource and a composite fishery abundance map is shown on page 18. These are results of planned jigging surveys carried out during 2010-11. The main period of abundance is for 6 months from October to March with peak during December - January.

The stock abundance of *S. oualaniensis* has been worked out based on scientific surveys in the Arabian Sea during 2010-11 and rendered in GIS format. Many areas between the Lakshadweep Islands show abundance in excess of 5 tonnes/ km^2 during the post and pre-monsoon periods.

The total stock of *S. oualaniensis* in the world's ocean is estimated to be between 8-11 million tonnes. Studies indicates that *S. oualaniensis* dominates the epipelagial zone of the Arabian Sea both in number and biomass and that the mean biomass is estimated as 4.5 t km^{-2}. The most promising region for a large-scale fishery of *S. oualaniensis* is the Arabian Sea with the fishable stock estimated as between 1.0 and 1.5 million tonnes.

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